Department of Meteorology

Exploiting energy & water cycle diagnostics to assess ongoing climate change

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Thanks to Caroline Wainwright, Emily Black, Chunlei Liu, Tim Andrews (Met Office), Kate Willett (Met Office), Viju John (EUMETSAT), Tim Trent (Leicester)

Introduction

Assessment of climate change is based on multiple lines of evidence spanning observations, simulations and physical understanding as exemplified in the recent Intergovernmental Panel on Climate Change report. Here, Earth Observation data is combined with reanalyses & simulations to advance physical understanding and add value to future projections.

(1) The climate sensitivity pattern effect

- Climate feedback parameter, **λ = d(N – F)/dT**

N is Net top of atmosphere flux, **F** is Radiative Forcing, **T** is surface temperature. *Details in Andrews et al. (2022) JGR in press.*

- Climate sensitivity (**-1/ λ**) varies as ΔT warming pattern changes
- Simulations and observations show that a "La Niña-like" pattern of warming since 1980 supressed climate sensitivity
- This can explain lower rate of warming relative to coupled simulations of long term response to CO_2 increases (Fig. 1)

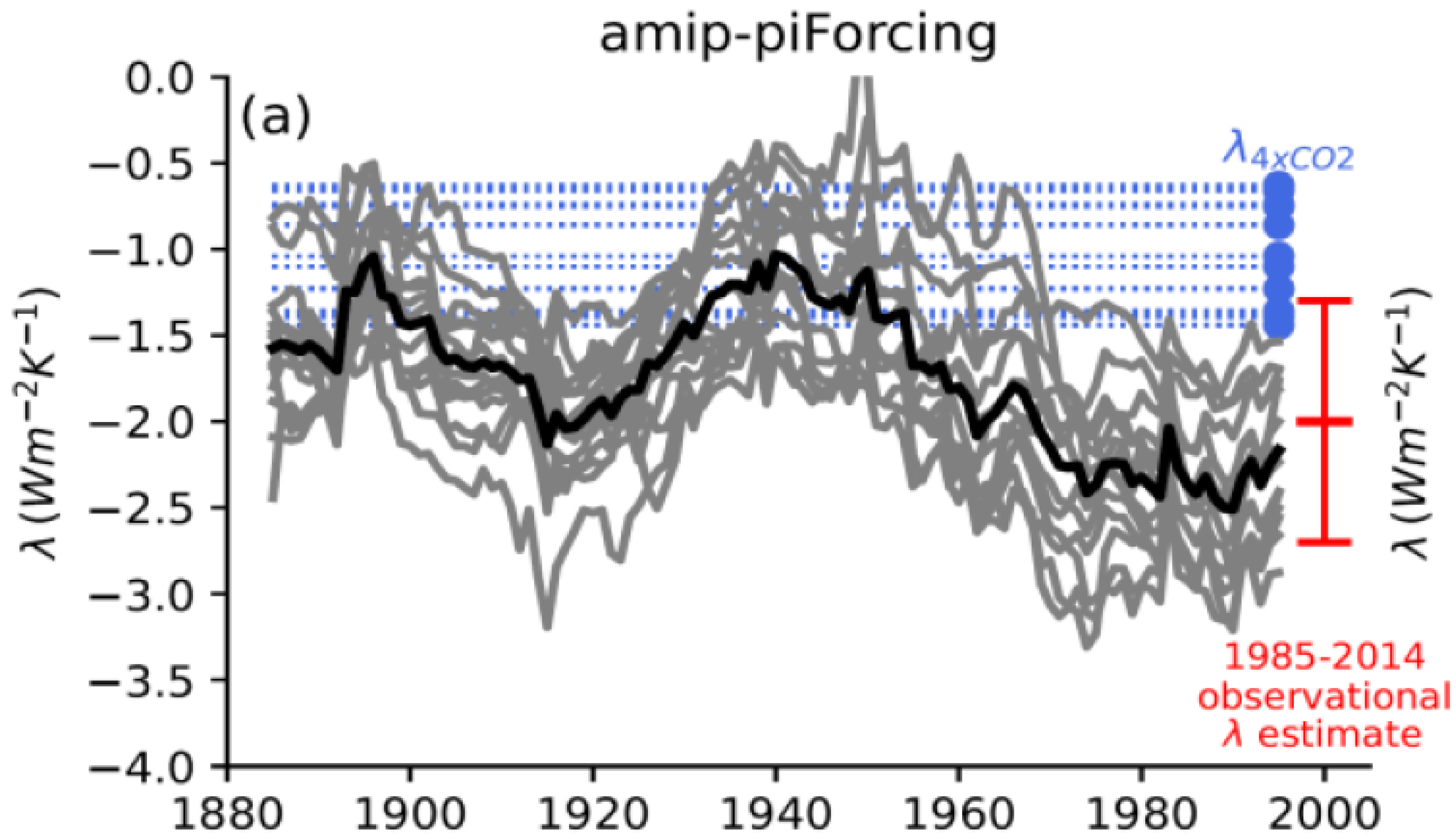

Figure 1: climate feedback (λ) in simulations using observed SST compared to coupled $4xCO_2$ experiments & the DEEP-C estimate

(2) Global water vapour changes

- Evaluation of global changes in water vapour 1979-2020

Satellite data (SSMIS, SMMR, AIRS, HIRS, AMSU/MHS), ground-based observations (HadISDH), ERA5 reanalysis, amip/historical CMIP6 simulations

- Water vapour increases with surface **T** consistent with thermodynamics & amplifying climate feedback (Fig. 2)

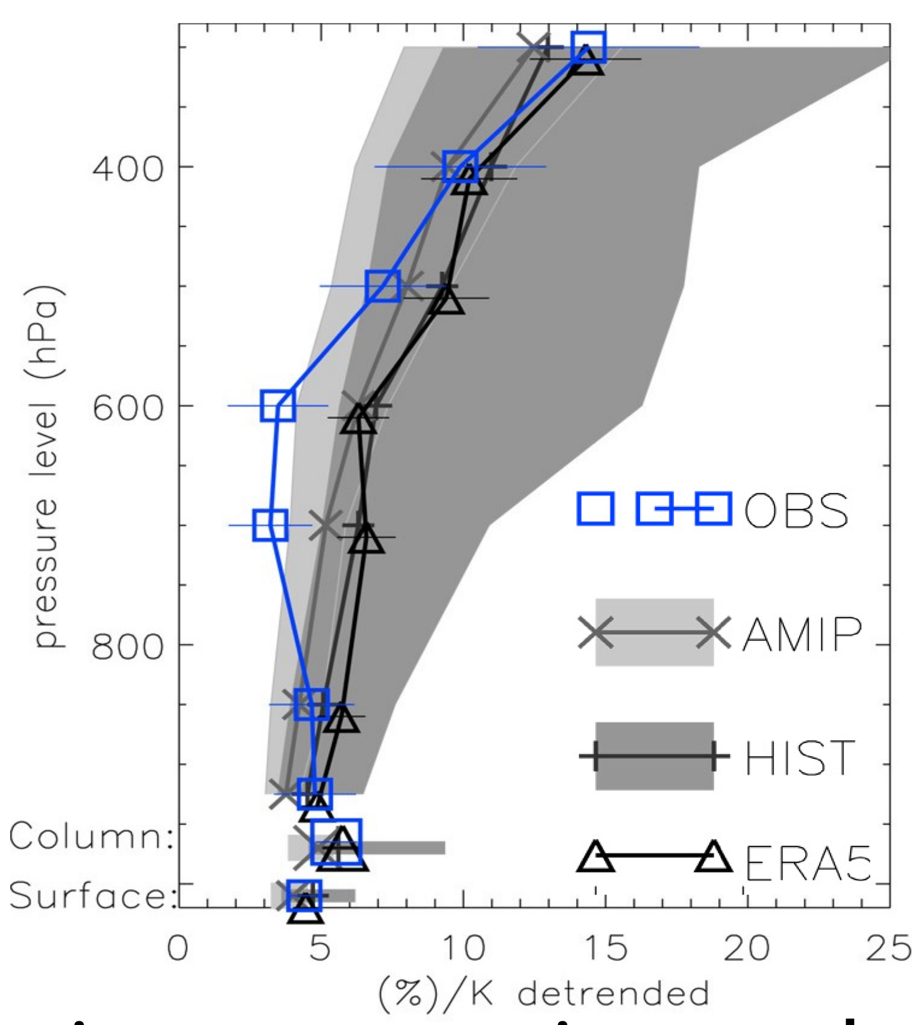

Figure 2: sensitivity of tropospheric water vapour to interannual changes in surface temperature (T). ***Allan et al. (2022) JGR***

(3) Intensification of dry seasons

- Observations (CHIRPS/TAMSAT/MSWEP), ERA5 reanalysis & CMIP6 simulations used to assess dry season intensity change
- Recent trends in dry spell length during the dry season are consistent with future projections (Fig. 3)
- Recent trends over South America and West Africa reflect a mix of natural and human caused drivers
- Longer dry spells over north-east South America linked with a strengthening land-ocean temperature contrast and a warmer North Atlantic Ocean. *Wainwright et al. (2022) GRL*
- Continued warming of climate will further intensify dry seasons, damaging crops and forests

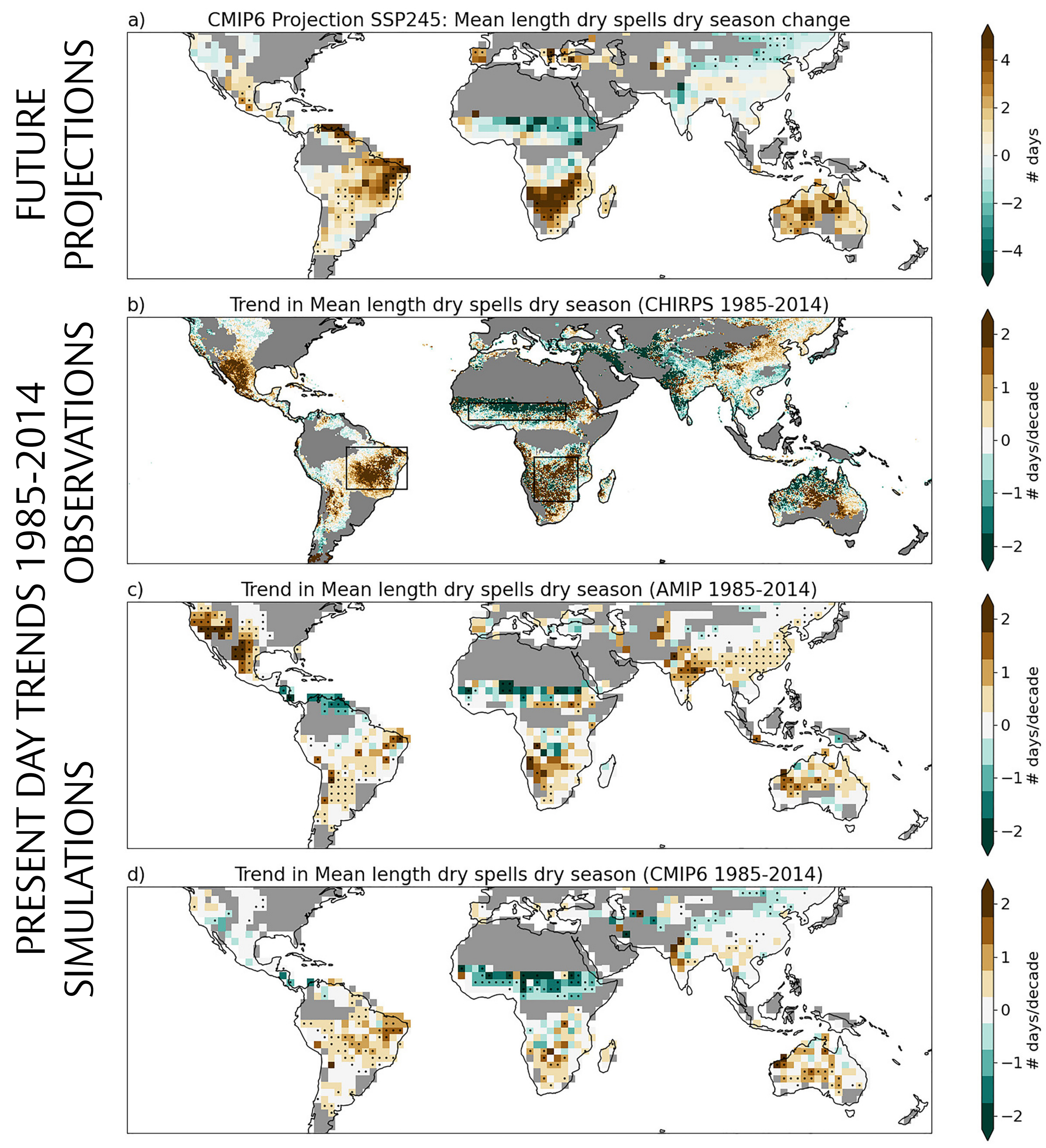

Figure 3: present day trends in dry season consistent with future projections over Brazil, southern Africa, Australia (longer dry spells) and west Africa (shorter dry spells).

References

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2. Allan, RP, KM Willett, VO John, T Trent (2022) Global changes in water vapor 1979-2020, *J. Geophys. Res*,, 127, doi: 10.1029/2022JD036728
3. Wainwright, CM, RP Allan, E Black (2022) Consistent trends in dry spell length in recent observations and future projections, *Geophys. Res. Lett.*, 49, doi: 10.1029/2021GL097231

Acknowledgements

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